AMENDMENTS TO THE SPECIFICATION:

Please amend the caption on page 1, line 6, as follows:

BACKGROUND ~~OF THE INVENTION~~

Please amend the paragraph beginning at page 2, line 17, and continuing to page 2, line 22, as follows:

Fig. 2 schematically illustrates uplink diversity in a WCDMA system, in which a mobile terminal 10 establishes radio links with multiple base stations (or node B[[:]]s) 20-1 and 20- and/or sectors simultaneously. Softer handover, also referred to as intersector diversity, here involves the reception of signals from the mobile terminal at different sectors within the same base station 20 followed by maximum ratio combining (MRC) on soft baseband signals in the MRC combiner 22 prior to channel decoding in the channel decoder 24.

Please amend the paragraphs beginning at page 4, line 8, and continuing to page 5, line 13, as follows:

The ~~present invention~~ technology disclosed herein overcomes these and other drawbacks of the prior art arrangements.

It is a general object of the technology disclosed herein~~present invention~~ to improve the performance of a wireless communication network such as a digital cellular network.

It is an object of the technology disclosed herein~~invention~~ to more optimally exploit signals from multiple base stations or similar receiving nodes in a wireless network. In particular, it is desirable to improve the uplink signal processing in a cellular network.

Yet another object of the technology disclosed herein~~invention~~ is to find a way to keep the costs for transporting the data required for the purpose of uplink signal processing at a reasonable level.

It is a particular object to provide a method and system for detection of signal information in a wireless communication network.

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It is also an object of the technology disclosed herein~~invention~~ to provide a network node for signal detection in a wireless communication network.

~~These and other objects are met by the invention as defined by the accompanying patent claims.~~

The technology disclosed herein~~invention~~ considers a plurality of receiving nodes such as base stations in a wireless network. Each receiving node converts a superposition of signals received from a plurality of transmitting nodes such as mobile terminals to produce soft complex signal information. A basic idea according to the technology disclosed herein~~invention~~ is to collect soft complex signal information associated with the considered plurality of receiving nodes over a transport network, and jointly detect signal information transmitted from at least a subset of the plurality of transmitting nodes based on the collected soft complex signal information. The collected soft signal information generally retains phase and amplitude information, and the transmitted signals are preferably detected in a joint detection process based on a complex channel representation and the collected soft signal information.

Please amend the paragraph beginning at page 5, line 21, and continuing to page 5, line 25, as follows:

Instead of per-user combining, the technology disclosed herein~~invention~~ provides joint detection of a plurality of transmitting nodes or mobiles. The technology disclosed herein~~invention~~ does not treat interference from other transmitting nodes as unstructured noise, in clear contrast to cellular systems of today. In effect, the signal processing approach suggested by the technology disclosed herein~~invention~~ rather strives to cancel such interference.

Please amend the paragraph beginning at page 6, line 6, and continuing to page 6, line 17, as follows:

In a practical realization, a complex channel gain matrix may be determined by explicit channel estimation. Alternatively, different combinations of complex channel

gain matrix and symbol hypothesis vector may be tested in a joint search procedure to find an optimal symbol hypothesis vector that will then represent the detected signal information. Any general detection algorithm, such as Zero Forcing (ZF), Maximum Likelihood Detection - Multi-User Detection (MLD - MUD) and Linear Minimum Mean Squared Error (LMMSE), may be used by the <u>technology disclosed herein</u>~~invention~~. Once detected, the signal information may be used as a basis for subsequent decoding processes such as error correction decoding and source decoding. Optionally, the decoding process can be considered as an integrated part of the detection process, e.g. by using multi-user based decoding. This means that detection can be done per bit or symbol or per sequence of bits or symbols, for multiple users.

Please amend the paragraph beginning at page 7, line 1, and continuing to page 7, line 11, as follows:

Therefore, the <u>technology disclosed herein</u>~~invention~~ also proposes a distributed approach to the novel multi-sensor processing scheme. The distributed approach is based on partitioning receiving nodes into multiple groups, and collecting, for each group, soft complex signal information associated with the receiving nodes of the group, and finally performing group-wise joint detection based on the collected information. More particularly, on group level, the joint detection is preferably performed based on the collected soft complex signal information associated with the considered group and a complex channel gain sub-matrix related to the receiving nodes of the group and the relevant transmitting nodes. The rationale is that interference only has a limited meaning at very far distances, and hence it makes little sense to distribute soft baseband information outside a rather local neighborhood.

Please amend the paragraph beginning at page 8, line 1, and continuing to page 8, line 2, as follows:

The technology disclosed herein~~invention~~ also provides a procedure for performing iterative detection of signal information based on distributed successive interference cancellation.

Please amend the paragraph beginning at page 8, line 10, and continuing to page 8, line 27, as follows:

The technology disclosed herein~~invention~~ offers the following advantages:

- Improved network performance;
- Optimal formulation for uplink signal processing in a digital cellular network;
- More optimal exploitation of signals from multiple base stations;
- Alternatives for reducing the costs for transporting soft complex signal information (distributed approach and/or compression);
- Integrated interference cancellation in the uplink signal processing; and
- Reduced transmit power consumption, since transmit power can be controlled with reference to the noise floor (as interference is cancelled to a large extent).

Other advantages offered by the present technology disclosed herein~~invention~~ will be appreciated upon reading of the below description of the example embodiments~~-of the invention~~.

Please amend the paragraphs beginning at page 9, line 1, and continuing to page 10, line 10, as follows:

The technology disclosed herein~~invention~~, together with further objects and advantages thereof, will be best understood by reference to the following description taken together with the accompanying drawings, in which:

Fig. 1 is a schematic diagram illustrating an example of a classical MIMO system;

Fig. 2 is a schematic diagram illustrating uplink diversity in a prior art WCDMA system;

Fig. 3 is a schematic diagram illustrating a prior art uplink protocol based on the multiple-to-one relationship between base stations and mobile;

Fig. 4 is a schematic diagram illustrating an example of a centralized architecture and signal processing approach according to a preferred example embodiment~~ of the invention~~;

Fig. 5 is a schematic flow diagram illustrating a method according to a preferred example embodiment~~ of the invention~~;

Fig. 6 is a schematic block diagram illustrating an example of a preferred realization for multi-sensor processing according to an example embodiment~~the invention~~;

Fig. 7 is a schematic diagram illustrating an example of detection and decoding unit according to an exemplary example embodiment~~ of the invention~~;

Fig. 8 is a schematic diagram illustrating an exemplary architecture and signal processing approach according to an alternative example embodiment~~ of the invention~~;

Fig. 9 is a schematic diagram illustrating an example of a distributed architecture and signal processing approach according to a preferred example embodiment ~~of the invention~~;
Fig. 10 illustrates an example of a distributed architecture and signal processing approach according to an alternative example embodiment ~~of the invention~~;

Fig. 11 is a schematic diagram illustrating an example of the signal exchange in a distributed realization with optional successive interference cancellation according to a preferred example embodiment ~~of the invention~~;

Fig. 12 is a schematic block diagram illustrating a realization of multi-sensor processing including compression and de-compression of soft information according to an exemplary example embodiment ~~of the invention~~; and

Fig. 13 illustrates power control and link mode feedback in a system according to an exemplary example embodiment ~~of the invention~~.

Please amend the caption on page 10, line 15, as follows:

DETAILED DESCRIPTION ~~OF EMBODIMENTS OF THE INVENTION~~

Please amend the paragraph beginning at page 10, line 19, and continuing to page 11, line 19, as follows:

Fig. 4 is a schematic diagram illustrating an example of a centralized system architecture and signal processing approach according to a preferred example embodiment ~~of the invention~~. The network comprises a plurality of receiving nodes 120-1, 120-2, 120-3 such as base stations and a plurality of transmitting nodes 10 such as mobile terminals in a wireless network. Each receiving node 120 converts a superposition of signals received from a plurality of transmitting nodes 10 to produce soft complex signal information, and forwards soft complex signal information to a central node 130, typically over a transport network. The central node 130 may be a dedicated network node or implemented in an

RNC (Radio Network Controller), BSC (Base Station Controller) or SHOD (Soft Handover Device). The central node 130 jointly detects signal information from the plurality of transmitting nodes based the collected soft signal information, and typically performs subsequent decoding, such as error correction decoding and/or source decoding, based on the detected signal information.

The term detection shall however be interpreted in a broad sense. Detection can take place on bit level, symbol level or on sequences of bits or symbols. Detection may take place on coded information or on information bits. The former means that decoding is generally performed on a per-user basis after detection, whereas the latter means that the decoding is integrated and then performed on multiple users. As will be appreciated below, the technology disclosed herein~~invention~~ can also be implemented with successive or parallel interference cancellation.

The main benefit of this approach over other state-of-the-art techniques is that it enables/offers the optimal formulation for uplink signal processing, especially if all nodes in the wireless network are under consideration in a centralized approach. Instead of per-user combining, the ~~invention~~ technology disclosed herein provides joint detection of a plurality of transmitting nodes or mobiles. The invention does not treat interference from other transmitting nodes as unstructured noise, in clear contrast to cellular systems of today. In effect, the signal processing approach suggested by the technology disclosed herein~~invention~~ rather strives to cancel such interference.

Please amend the paragraph beginning at page 14, line 25, and continuing to page 17, line 12, as follows:

The overall flow of an exemplary multi-sensor processing procedure for multi-user detection according to a preferred example embodiment~~ of the invention~~ will now be summarized with reference to Fig. 5. In ~~step~~ act S1, each of a number of receiving nodes (base stations) converts a superposition of received signals into soft complex information,

such as digitized complex baseband signals. In act~~step~~ S2, complex baseband signals or similar soft signals are collected from the receiving nodes. In act~~step~~ S3, the complex channel gain matrix between the receiving nodes and the transmitting nodes is typically determined, e.g. by explicit channel estimation or based on the collected complex baseband information. In act~~step~~ S4, joint detection of signal information, such as symbols or sequences (code words), from multiple transmitting nodes is performed, preferably based on the collected soft complex information and the estimated complex channel gain matrix. As previously mentioned, acts~~steps~~ S3 and S4 may be integrated and performed jointly.

Fig. 6 is a schematic block diagram illustrating an example of a preferred realization for multi-sensor processing according to the technology disclosed herein~~invention~~, implemented in a cellular radio network. Consider a number of mobile terminals 10-1, ..., 10-M, each of which transmits a radio signal representing digital information to a number of base stations 120-1, ..., 120-N. Each base station typically includes traditional base station equipment, such as a radio frequency section (RF) 122, a medium frequency section (MF) 124 and an analog/digital converter (A/D) 126. Although the base station is illustrated as having a single receiving antenna, there is nothing that prevents the base station from using an advanced multi-antenna system. In this exemplary embodiment it is assumed that the received signals are quadrature amplitude modulated (QAM), for example 64 QAM. This means that the A/D converter 126 will produce a digital baseband signal including both in-phase (I) and quadrature-phase (Q) components, each with a resolution of, for example, 10-15 bits (fewer or more bits are possible). In this embodiment, these I and Q components represent soft information to be sent to a central decoding node 130, for example an RNC, BSC or SHOD. The soft information is forwarded to an encapsulating unit 128, which puts the information into packets suitable for transfer to the RNC/BSC 130 over a transport network. At the RNC/BSC 130, the soft information from the base stations 120-1, ..., 120-N is received by one or more decapsulating units 132, which retrieve the soft information. The soft I and Q components from the base stations are then forwarded to a detection and

decoding unit 134, which jointly detects the transmitted signals from the mobile terminals 10-1, ..., 10-M and subsequently decodes the detected signals. Alternatively, as mentioned earlier, decoding may be performed as an integrated part of the overall joint detection process.

Fig. 7 is a schematic diagram illustrating an example of detection and decoding unit according to the technology disclosed herein~~invention~~. In this particular example, the detection and decoding unit 134 comprises a module 135 for determining a complex channel gain matrix, a joint detection module 136 and a decoding module 137. The detection and decoding unit 134 receives soft complex baseband signals from multiple receiving nodes such as base stations. For example, the complex soft baseband signals may include I and Q components (or other soft information indicative of reliability) from multiple base stations. The I and Q components are transferred to the channel gain matrix determination module 135 for estimating respective complex channel gain estimates over one or more samples (e.g. over an entire frame) by means of conventional channel estimation techniques. The complex channel gain estimates are normally determined simultaneously, per base station or for all base stations at once, in a search procedure. The estimated complex channel gain matrix is forwarded to the detection module 136, which based on this complex channel gain matrix and the soft I and Q components jointly detects symbol information from the mobile terminals. Alternatively, each base station determines respective complex channel estimates related to the transmitting mobile terminals, and sends channel estimation symbols in the soft information to the central node. More information on multi-user channel estimation techniques can be found, e.g. in references [9, 10]. Once detected, the retrieved symbols are transferred to the decoding module 137, which performs decoding such as channel decoding/error correction decoding and/or source decoding to generated decoded data. While multi-user detection may be performed on symbols and subsequent per-user decoding is performed, one may also perform multi-user detection on sequences equivalent to multi-user decoding. Performing decoding as an integrated part of

the detection process implies that the detection module 136 may be configured for joint detection and decoding, and that a separate decoding unit 137 may be omitted.

Fig. 8 is a schematic diagram illustrating an exemplary architecture and signal processing approach according to an alternative example embodiment~~ of the invention~~. In similarity to the example of Fig. 4, the network comprises a plurality of receiving nodes 120-1, 120-2, 120-3 such as base stations and a plurality of transmitting nodes 10 such as mobile terminals. Each receiving node 120 converts a superposition of signals received from a plurality of transmitting nodes 10 to produce soft complex signal information. In this embodiment, a number of receiving base stations 120-1 and 120-3 transfer soft complex signal information to a so-called controlling base station 120-2. The controlling base station, which can be regarded as a "super base station", takes its own soft complex information and combines it with the soft complex information received from the other base stations in a joint detection process to detect the signal information from the transmitting mobile terminals.

Please amend the paragraphs beginning at page 18, line 1, and continuing to page 18, line 21, as follows:

Therefore, the technology disclosed herein~~invention~~ also proposes a distributed approach to the novel multi-sensor processing scheme. The distributed approach is based on partitioning receiving nodes into multiple groups, and collecting soft complex signal information associated with the receiving nodes of each group, and finally performing group-wise joint detection based on the collected information. The receiving nodes may be partitioned into groups based on e.g. geographical position or correlation characteristics. More particularly, on group level, the joint detection is preferably performed based on the collected soft complex signal information associated with the considered group and a complex channel representation such as a complex channel gain matrix related to the receiving nodes of the group and the relevant transmitting nodes. The rationale behind this distributed approach is that interference only has a limited

meaning at very far distances, and hence it makes little sense to distribute soft information outside a rather local neighborhood.

The problem associated with the transfer of large amounts of signal data over the transport network has been analyzed in reference [8], in the context of per-user combining. However, the solution proposed in reference [8] implies that each base station should decode the signal received from a mobile and transfer a decoded signal to the central exchange node, where the decoded signals are re-encoded, combined and finally decoded. The technology disclosed herein~~invention~~, on the other hand, suggests a solution to this type of problem based on distributed joint multi-user detection.

Please amend the paragraph beginning at page 20, line ?, and continuing to page 21, line 14, as follows:

Fig. 10 illustrates an example of a distributed architecture and signal processing approach according to an alternative example embodiment~~ of the invention~~, with somewhat looser requirements on how the receiving nodes 120 (e.g. base stations) may be partitioned into groups. The groups may include not only immediate neighbors, but also more distant neighbors. Still however, some form of locality is desired so that soft information does not have to be exchanged/distributed from nodes situated very far from each. In the example of Fig. 10, three main groups A, B and C are formed. As mentioned above, some groups, here group A and group B, may be associated with a designated signal processing node 130 that is responsible for collecting soft complex information and performing the required signal processing. In group B, a designated receiving node 120 is responsible for collecting soft complex information and performing signal processing. Decoded data from the three groups may be distributed to a so-called combining unit 140, which "combines" multiple copies of the same decoded data, thus performing some form of duplicate filtering. Higher layer protocols such as ARQ may be used after duplicate filtering.

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If it is not possible to directly detect all the relevant signal information from the considered mobile terminals, the technology disclosed herein~~invention~~ provides a procedure for performing iterative detection of signal information based on distributed successive cancellation of currently detected signal information from soft complex signal information.

Fig. 11 is a schematic diagram illustrating an example of the signal exchange in a distributed realization with optional successive interference cancellation according to a preferred example embodiment~~ of the invention~~.

Please amend the paragraph beginning at page 22, line 22, and continuing to page 23, line 12, as follows:

Fig. 12 is a schematic block diagram illustrating a realization of multi-sensor processing including compression and de-compression of soft information according to an exemplary embodiment~~ of the invention~~. The block diagram of Fig. 12 is similar to that of Fig. 6, except for the compression on the base station side and the corresponding de-compression on the detection and decoding side. By way of example, assume once again that the A/D converter 126 produces a digital baseband signal including both in-phase (I) and quadrature-phase (Q) components. Before these I and Q components are sent to the central RNC/BSC node, they are forwarded to a compressor 127, which compresses the soft information. The compressed soft information is forwarded to an encapsulating unit 128, which puts the information into packets suitable for transfer to the RNC/BSC 130 over the transport network. At the RNC/BSC 130, the compressed information from the base stations 120-1, ..., 120-N is received by one or more decapsulating units 132, which retrieve the compressed soft information. This compressed soft information is de-compressed in a set of de-compressors 133, which at least approximately restore the I and Q components originally sent from the respective base stations. The restored I and Q components are then forwarded to the detection and decoding unit 134.

Please amend the paragraph beginning at page 24, line 6, and continuing to page 25, line 8, as follows:

Although this aspect of the technology disclosed herein~~invention~~ is illustrated for a centralized architecture and signal processing approach, it is clear that each base station may be provided with a compressor as well as a de-compressor to support compression/de-compression of soft complex signal information also for distributed implementations.

For both centralized and distributed architectures, power control as well as link mode control (including modulation, coding and spreading) can be adjusted to take advantage of the new signal processing architecture. In doing that, power control may also operate between multiple base stations. Fig. 13 illustrates power control and link mode feedback in a system according to an exemplary embodiment~~ of the invention~~. In a simple network, soft complex information is collected for joint detection and subsequent decoding. Various suitable quality indicators from the detection unit 136 and/or an optional separate decoding unit 137 may be transferred to a radio resource management unit 138 for suitable power control and/or link mode feedback to the mobile terminals 10. In traditional power control schemes, the power control policy is to exceed any interfering signal with some margin. However, as the ~~invention~~ technology disclosed herein strives to cancel interference by advanced multi-sensor processing, transmit power will rather be controlled with reference to the noise floor. This change in power control objective may have an impact on the power control protocol, where power control decisions are taken and power control PDUs are sent. The fact that power consumption is reduced, since transmit power can be controlled with reference to the noise floor, leads to even more efficient detection and decoding. This of course leads to even better power control settings, which in turn leads to even better interference cancellation and so on. Power control can be accomplished in several ways, e.g. through an inner power control loop that compares instantaneous signal quality, such as signal to interference (and noise) ratio with a target value, Γ. By adapting transmit power rapidly, any degradation in signal quality due to fast fading can be counteracted. Power control can also be performed on a slower basis with reference to an average power level.

Outer loop power control may derive its input from packet error rate or block error rate figures, and adjust the signal to interference ratio target in response to fulfill desired performance criteria for each link. The power control can, similarly to existing cellular systems, operate in a distributed fashion, i.e. each link is individually controlled, or alternatively a partially or fully centralized method may be adopted.